Lecture On

MAP PROJECTION AND COORDINATE SYSTEM

Training Course on
'Marine GIS for Operational Oceanography'

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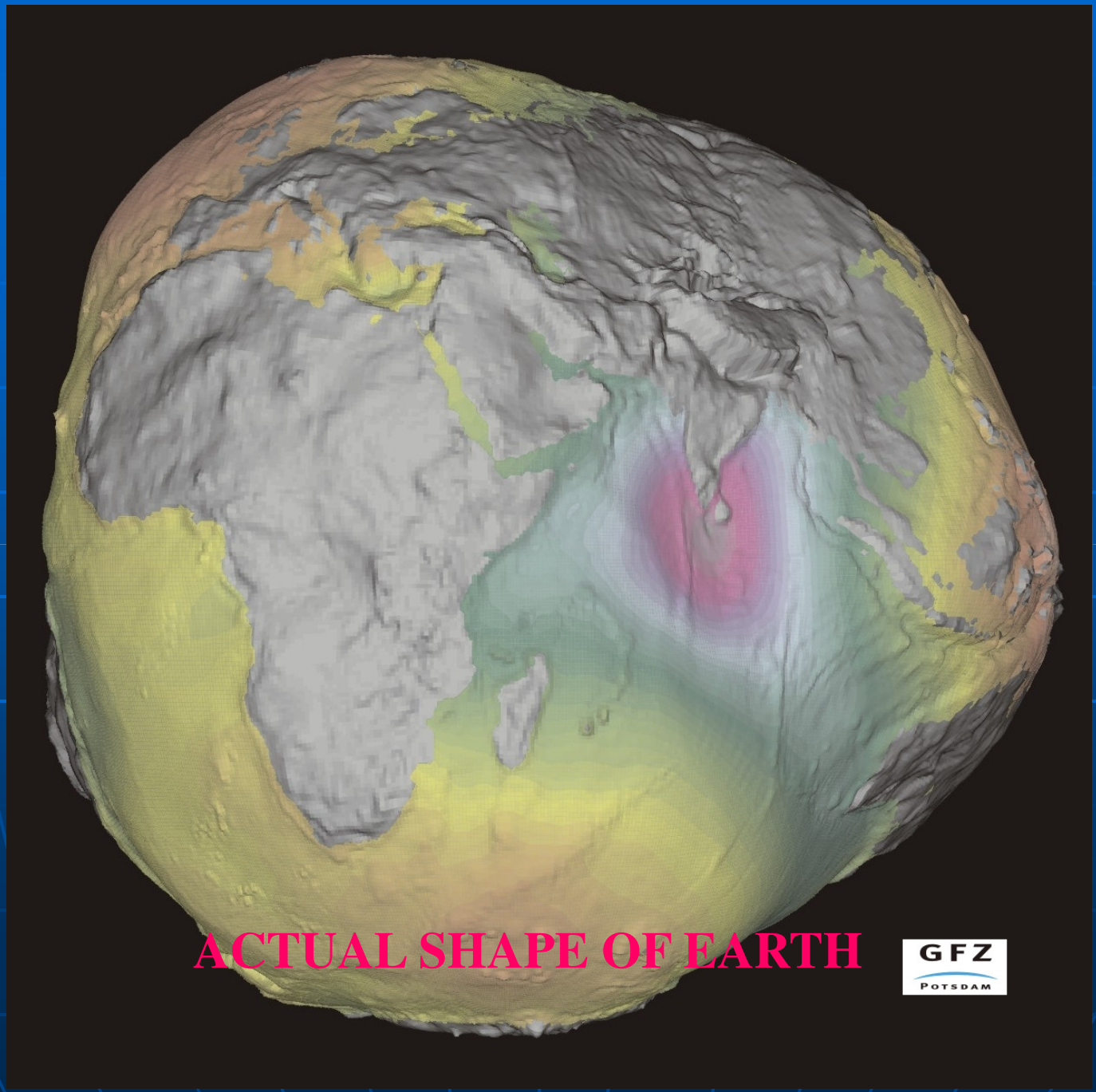
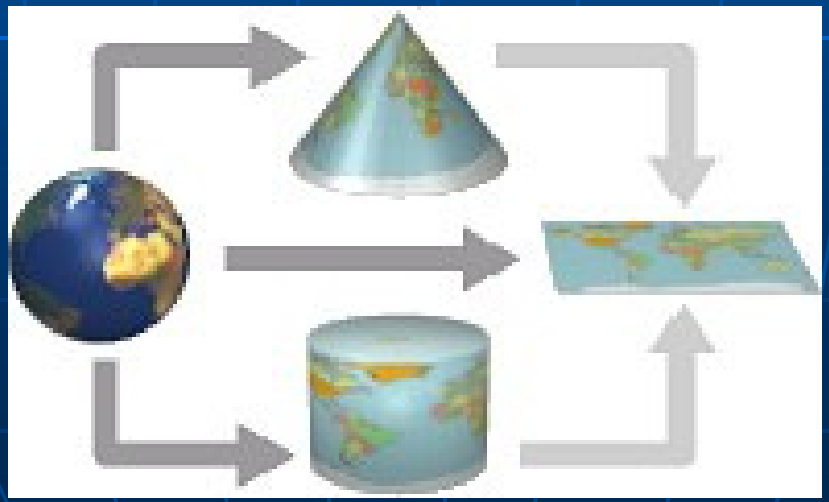
EARTH AS WE SEE FROM SPACE


ACTUAL SHAPE OF EARTH
GFZ
POTSDAM

Projection

- Transformation of Three Dimensional Space onto a two dimensional map
- A systematic arrangement of intersecting lines on a plane that represent and have a one to one correspondence to the meridians and parallels on the datum surface



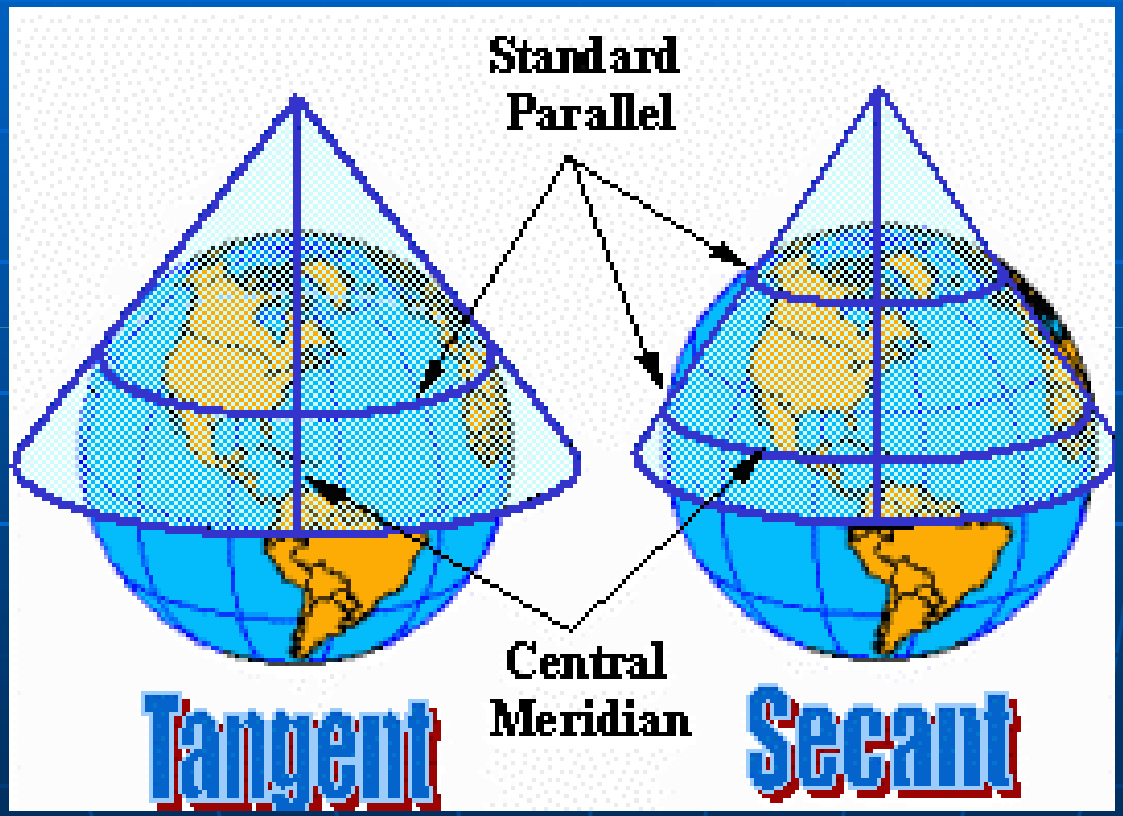
Classification

- A) Based on Extrinsic property
- Nature:
  - Plane, Cone, Cylinder
- Coincidence:
  - Tangent, Secant, Polysuperficial
- Position:
  - Normal, Transverse, Oblique

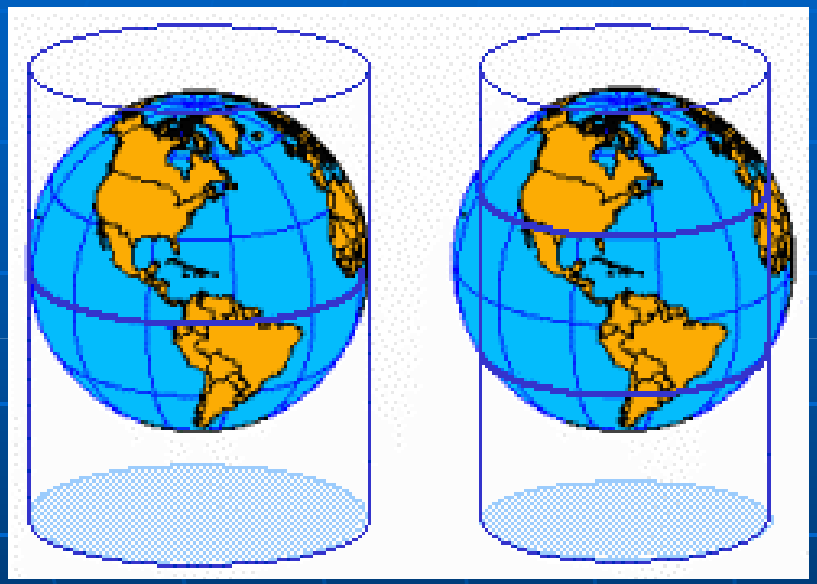
Classification contd.

- B) Based on Intrinsic Property
- Property of Projection:
  - Equidistant
  - Conformal or Orthomorphic
  - Equivalent or Equal area
- Generation:
  - Geometric, Semi Geometric, Mathematical

Conic Projections

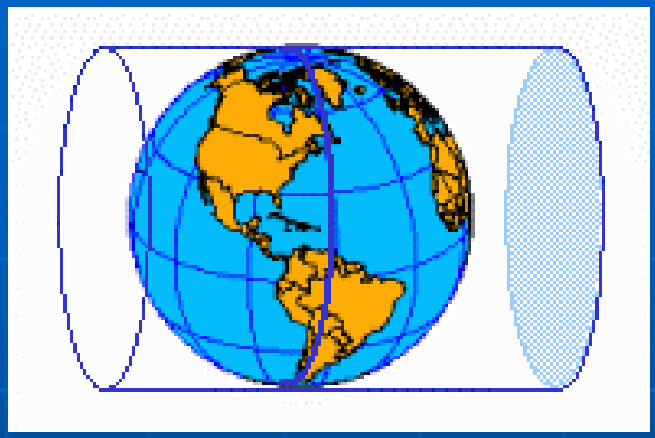


Cylindrical Projections

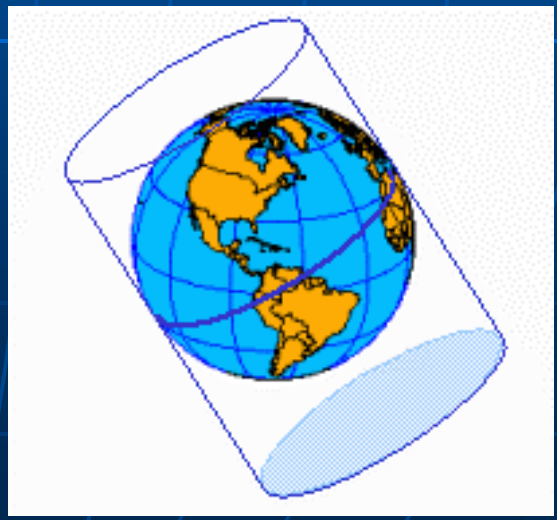


Tangent

Secant

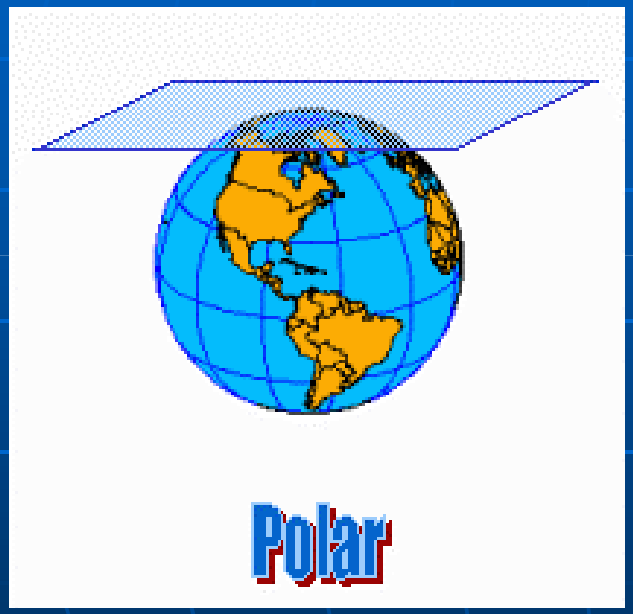


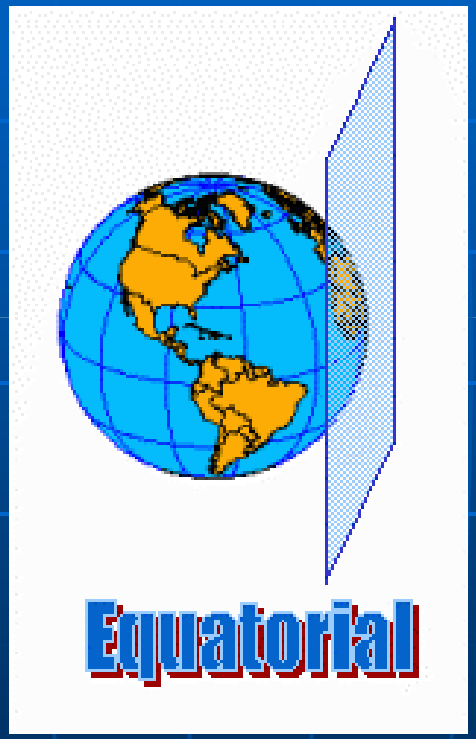
Transverse



Oblique

Azimuthal Projections



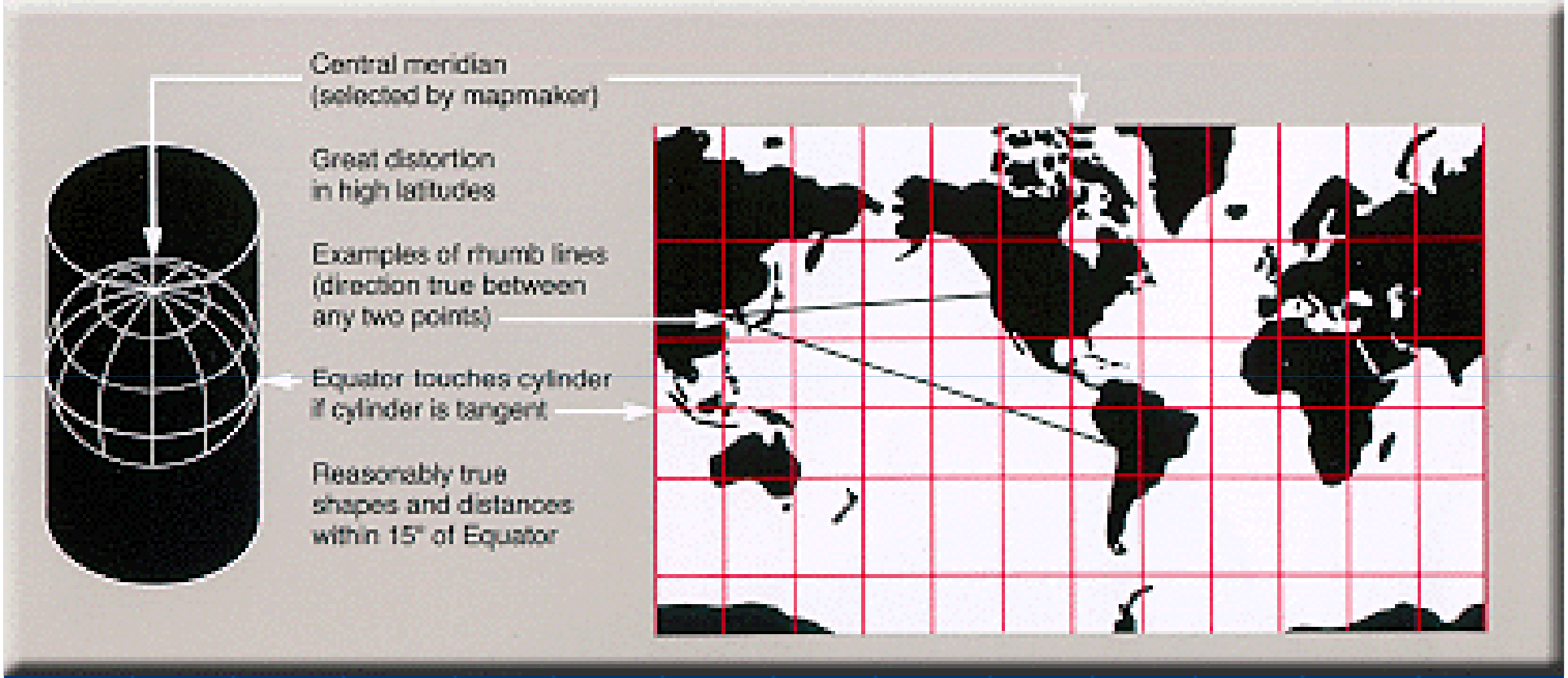


Cylindrical Map Projections

- Cylindrical map projections are made by projecting from the globe onto the surface of an enclosing cylinder, and then unwrapping the cylinder to make a flat surface
  - Mercator
  - Transverse Mercator
  - Cassini-Soldner

Mercator Projection

- Cylindrical, Conformal
- Meridians are equally spaced straight lines
- Parallels are unequally spaced straight lines
- Scale is true along the equator
- Great distortion of area in polar region
- Used for navigation

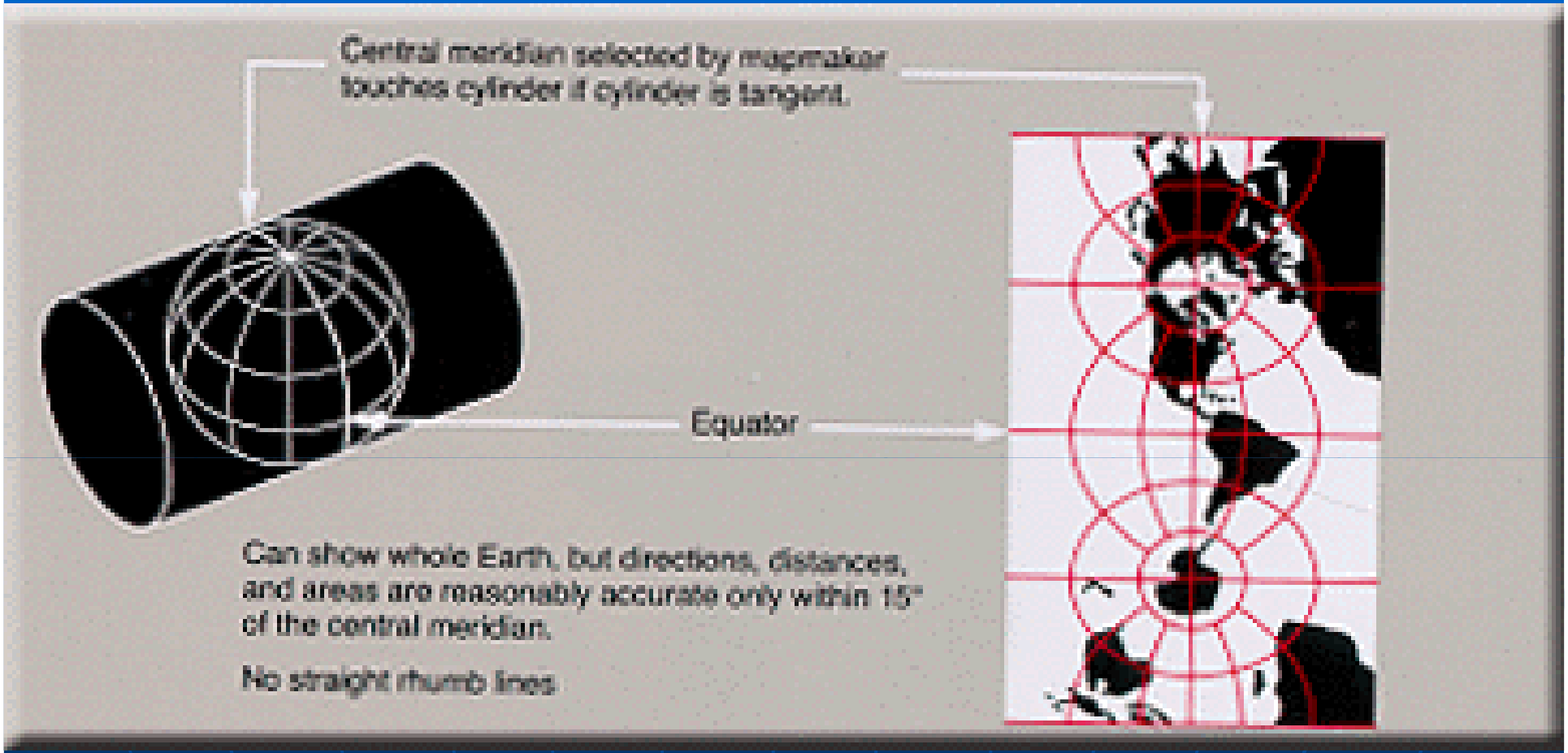


REGULAR CYLINDRICAL PROJECTION:

THE MERCATOR

Transverse Mercator Projection

- Cylindrical (Transverse)
- Conformal
- Central meridian and equator are straight lines
- Other meridians and parallels are complex curves
- Used extensively for quadrangle maps at scales from 1:24,000 to 1:250,000
- For areas with larger north-south extent than east-west extent



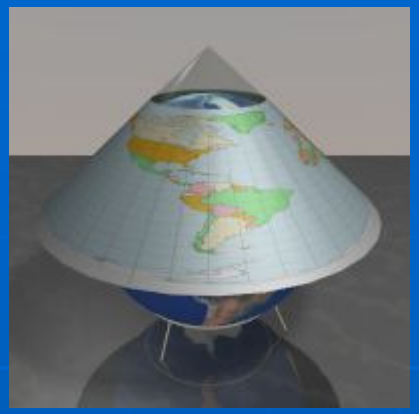
TRANSVERSE CYLINDRICAL PROJECTION:

THE TRANSVERSE MERCATOR

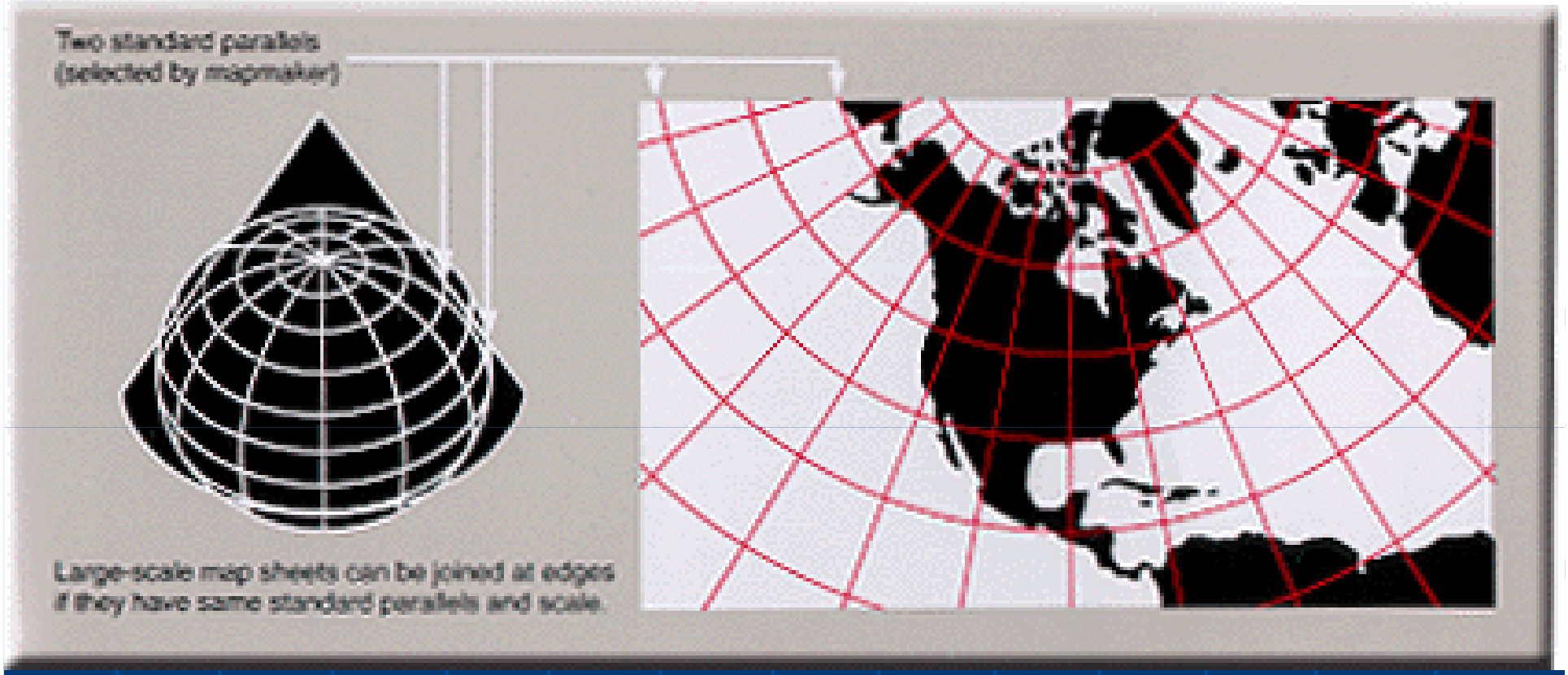
Cassini- Soldener Projection

- Cylindrical, Tangent, Transverse
- Equidistant
- Cylinder is tangent along the meridian centrally located
- Scale deteriorates away from central meridian
- Normally used in 70 km belt from the central meridian, as linear distortion factor at 70 km is 1.00006
- Used for old cadastral surveys in India.

Conic Projections



- For a conic projection, the projection surface is cone shaped
- Locations are projected onto the surface of the cone which is then unwrapped and laid flat

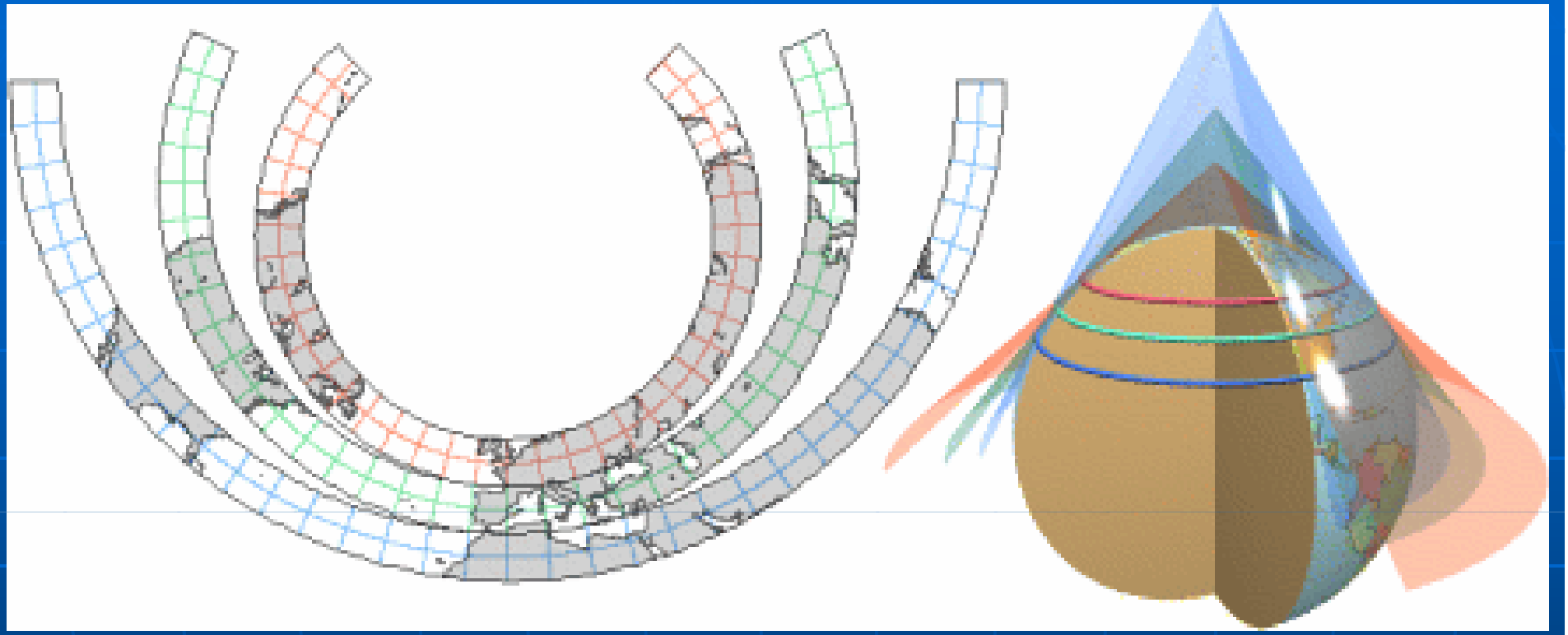


LCC PROJECTION

Lambert Conformal Conic Projection

- Conical, Conformal
- Parallels are concentric arcs
- Meridians are straight lines cutting parallels at right angles.
- Scale is true along two standard parallels, normally, or along just one.
- It projects a great circle as a straight line – much better than Mercator
- Used for maps of countries and regions with predominant east west expanse
- Used for plane coordinate system (SPCS) in USA

LCC PROJECTION



Three partial equidistant conic maps, each based on a different standard parallel, therefore wrapped on a different tangent cone (shown on the right with a quarter removed plus tangency parallels). When the number of cones increases to infinity, each strip infinitesimally narrow, the result is a continuous polyconic projection

Polyconic Projection

- In this projection all parallels are projected without any distortion
- Scale is exact along each parallel and central meridian.
- Parallels are arcs of circles but are not concentric.
- It is neither conformal nor equal area.

Polyconic Projection contd.

- Central meridian and equator are straight lines; all other meridians are curves.
- Central Meridian cuts all parallels at 90 degrees
- Free of distortion only along the central meridian.
- It has rolling fit with adjacent sheets in EW direction.
- Was used in India for all topographical mapping on 1:250,000 and larger scales.

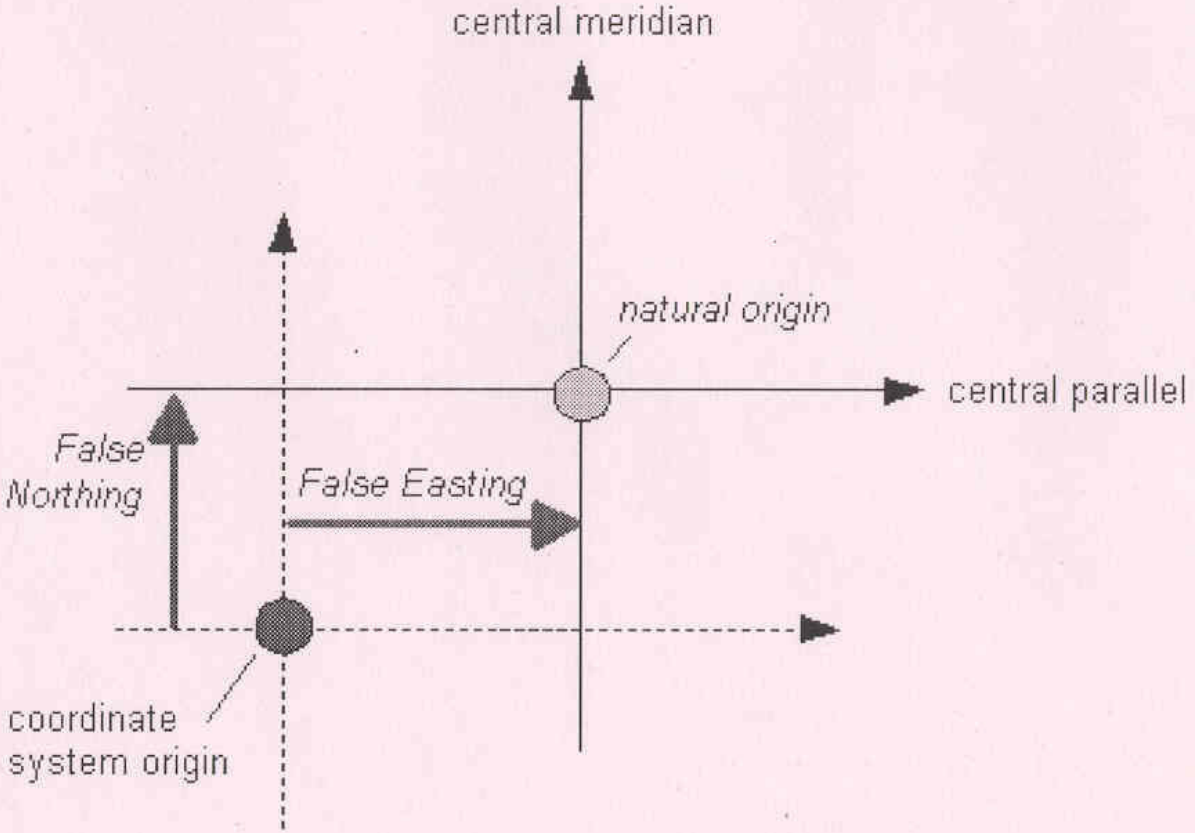
Azimuthal Projections

- For an azimuthal, or planar projection, locations are projected forward onto a flat plane.
- The normal aspect for these projections is the North or South Pole.

- Grid Distance = True Distance * Scale Factor
- Scale Error = True Distance – Grid Distance
- Scale Error for Lambert Grid = 1 / 824
- Scale Factor = 1 – 1 / 824 = 823 / 824 = 0.99878

False Northing and False Easting

- Calculating coordinates is easier if negative number aren't involved.
- State Plane and Universal Transverse Mercator coordinates have fixed FE & FN
- Expressed in coordinate units, not degrees.

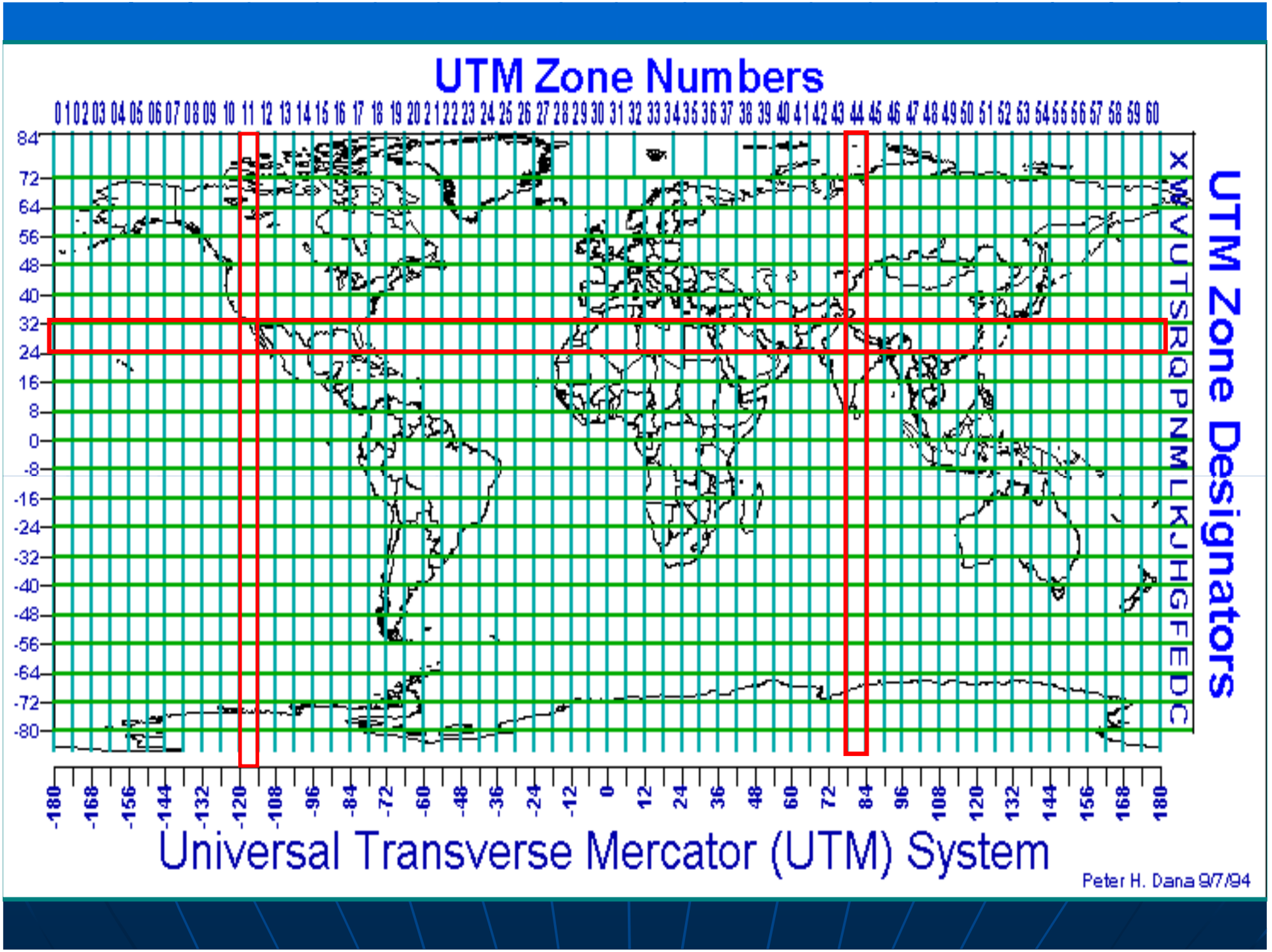


SPECIFYING AN ORIGIN SHIFT:

THE FALSE EASTING AND FALSE NORTHING

Universal Transverse Mercator

- Particular case of Transverse Mercator Projection.
- The earth between latitudes 84° N and 80° S, is divided into 60, 6° wide (called gores);
- Latitude origin – the equator
- Assumed (false) northing (y): 0 metres for northern hemisphere; 10,000,000 metres for southern hemisphere
- Assumed (false) easting (x): 500,000 metres; scale factor at the central meridian: 0.9996


UTM Zone Numbers
0 1 0 2 0 3 0 4 0 5 0 6 0 7 0 8 0 9 1 0 1 1 1 2 1 3 1 4 1 5 1 6 1 7 1 8 1 9 2 0 2 1 2 2 2 3 2 4 2 5 2 6 2 7 2 8 2 9 3 0 3 1 3 2 3 3 3 4 3 5 3 6 3 7 3 8 3 9 4 0 4 1 4 2 4 3 4 4 4 5 4 6 4 7 4 8 4 9 5 0 5 1 5 2 5 3 5 4 5 5 5 6 5 7 5 8 5 9 6 0
84
72
64
56
48
40
32
24
16
8
0
-8
-16
-24
-32
-40
-48
-56
-64
-72
-80
X W V U T S R Q P N M L K J H G F E D C
UTM Zone Designators
-180 -168 -156 -144 -132 -120 -108 -96 -84 -72 -60 -48 -36 -24 -12 0 12 24 36 48 60 72 84 96 108 120 132 144 156 168 180
Universal Transverse Mercator (UTM) System
Peter H. Dana 9/7/94

Universal Transverse Mercator

- There are four elements in a UTM Grid reference and these are:
- 1. UTM Grid Zone number.
- 2. A pair of letters identifying a 100000 metre grid square.
- 3. An Eastings and northings value in metres.
- 4. A northings value in metres.
- To keep distortion within acceptable limits narrow longitudinal portions of Earth's surface are mapped on to the projection surface.

UTM SCALE FACTOR

As we know, the farther the departure from the true origin of the projection the greater the distortion. In the UTM projection distortion increases as the distance from the Central Meridian increases.

If the projection plane is resting on the surface of the Globe distances measured along the Central Meridian will be true. Away from the Central Meridian distances become increased. That is, if a distance is measured between two points on the Earth's surface, that distance will be increased after the two points have been projected.

Especially in topographic mapping these distortions have to be kept within certain limits. It was for this reason that an artificial scale factor of 0.99960 was given to the Central Meridian of a UTM Grid Zone. Thus, 1000 metres measured along a meridian on the Earth's surface will become 999.6 metres on the projection if that meridian is a UTM Central Meridian. This is contraction of 40 cm per kilometre. If this was not done the distortion at the extreme edge of a zone would be too great.

The approximate formula for calculating the scale factor at a given point is S.F. = $1 + (E^2 \div 2.R^2) - 0.0004$, where E is the difference in Eastings between the point in question and the Central Meridian and R is the radius of the Earth.

The application of the scale factor of 0.99960 to the Central meridian has the effect of making the projection secant.

Why was the Scale Factor 0.99960 chosen ? It is based on the accuracy of measurement required. An acceptable accuracy requirement was decided upon and this was such that a distance of 50 cm should be measured to an accuracy of 0.2 mm. If 0.2 mm is divided into 50 the answer is 2500. An acceptable accuracy would be 2499 or 2501 units for a distance actually measuring 2500 units

2499 ÷ 2500 = 0.99960 and that is how this scale factor was determined.

As the distance increases from the Central Meridian, East or West, the scale factor increases until it becomes exactly 1.00000 at 180 km to the West and to the East of the Central Meridian.

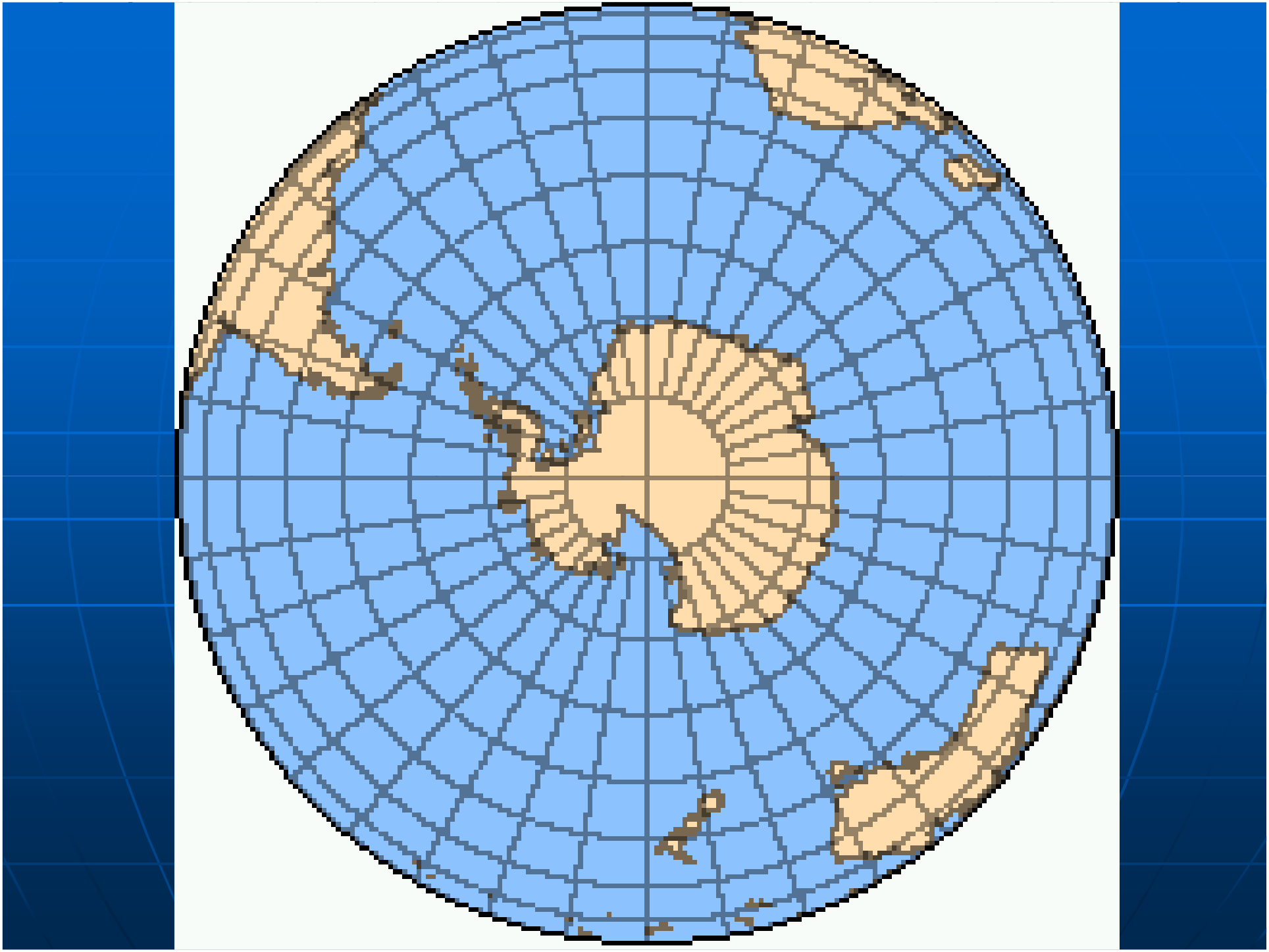
180 km is 180000 metres. To the West of the Central Meridian the scale factor is 1.00000 at 320000mE (500000m – 180000m = 320000m

Remember that the Central Meridian is at 500000mE.

Thus, all the way along the 320000mE and 680000mE grid lines the scale factor is exactly 1.00000. Beyond these two grid lines, West and East respectively, the scale factor becomes more than 1.00000 and reaches the maximum at 40 km beyond the edge of a zone.

Universal Polar Stereographic (UPS)

- Defined above 84 degrees north latitude and 80 degree south
- Conformal
- Meridians are straight lines
- Parallels are circles
- Scale increases from center point
- Used in conformal mapping of polar regions



State Plane Coordinates

- Lambert Conformal Conic Projections are used for rectangular zones with a larger east-west than north south extent.
- Transverse Mercator projections are used to define zones with a larger north-south extent.
- One State Plane zone in Alaska uses an oblique Mercator projection.

Projection Parameters

- To define the coordinate system completely, it is not sufficient simply to name the kind of projection used, it is also necessary to specify the projection parameters.
- The set of parameters required depends on the kind of projection.
- The central meridian of the projection for cylindrical, where it touches the ellipsoid surface.

Projection Parameters contd.

- The standard parallel(s) for conic projections.
- The false easting and false northing
- The units
- Reference ellipsoid

Choosing a map Projection

- The choice of map projection is made to give the most accurate possible representation of the geographic information, given that some distortion is inevitable. The choice depends on:
- The location
- Shape
- Size of the region to be mapped
- The theme or purpose of the map


THANK YOU!